REMR Technical Note CS-ES-1.13

Site Inspection and Sampling Concrete Damaged by Alkali-Silica Reaction

Purpose

The purpose of this technical note is to provide guidance for the investigation of concrete problems in which alkali-silica reaction (ASR) is suspected of contributing to concrete deterioration.

Application

Routine periodic inspections may be made to determine the condition of concrete structures, or an investigation may be required to address a specific problem. Any investigation should include a determination of the contribution that ASR might have had on concrete deterioration or on problems with operations at the structure.

Growth of concrete resulting from ASR causes cracking that appears as a dark gray buildup along the crack openings on horizontal surfaces (Figure 1), white exudations along vertical surfaces, and sometimes misalignment between structural members (Figure 2). Surface map cracking and misalignment are classical evidence of the physical manifestation of ASR. However, while these physical conditions are suggestive of possible ASR, a site investigation can neither confirm nor discount the presence of ASR with confidence. The purpose of the site investigation is to identify those features that are consistent with possible ASR deterioration so that appropriate laboratory assessment of the concrete may be conducted.

Sampling and sample preservation are important if useful information is to be obtained from any testing program designed for the investigation of the concrete.

Inspection and Sampling

The purpose of an investigation is to gain some understanding of the effect of ASR in the structure. Obtaining large numbers of random samples in strict compliance with sound statistical procedures is often not practical either physically or economically. It is important to obtain enough concrete representative of difference in materials used in construction, such as changes

Figure 1. Cracking in ASR-affected concrete

Figure 2. ASR-affected concrete, showing displacement

in cement, use of pozzolan, and alternate mixture proportions. Differing environmental conditions including loading, weathering, and age may influence the behavior of the concrete and should be considered during the investigation. For a lock wall, this consideration may involve taking cores from above upper pool elevation, in the zone between upper and lower pool

elevations, and possibly below lower pool elevation. Other areas may be of interest depending on the requirements of the investigation.

Prior to site inspection, many of the decisions concerning the number of cores necessary for the investigation can be made by reviewing documents associated with the project. Depending on the priority set by the sponsor, certain sections in the structure may be of particular interest because of continuing problems or structural importance. It is useful then to understand the differences in construction methods, materials used, and environmental variations. Table 1 lists sources where this type of information may be obtained.

Table 1
Sources for Information on Construction, Materials, and Environment

Source	Type of Document
Construction records	Drawings Materials specifications Construction records Materials source Environmental data Conditions
Periodic inspection reports	Deterioration Problems Repairs
Other documents	Memoranda Letters Planning documents Maintenance records
Interviews	Supervisor Project engineer Workers

A desk study should be performed by the individual doing the inspection. Details that can be obtained in advance include:

a. Structure identification: Name and location

b. Age: Start date, completion date, and date of remedial work

c. Structural information: Loading, construction details, reinforcement, etc.

d. Concrete: Mixture proportion, sources of materials, certificates, and test results

e. Other structures: Information on other structures in the area with similar materials

f. Environmental conditions:	Temperature, exposure to elements, deicing salts, and industrial solutions
g. Physical characteristics:	Length changes, dynamic measurements, and strength measurements

Sampling

The investigation of ASR-affected concrete may take many directions depending on the requirements of the project. Often in situ nondestructive testing is performed to determine the quality of the existing concrete and the extent of possible damage. The results of nondestructive testing can show areas of distress that may require further investigation. A long-term monitoring program may be instituted for critical elements within a structure. This normally involves the installation of dimensional monitoring devices that can be read manually or through the use of an automatic data acquisition system.

Sampling is necessary to diagnose the cause of distress and to provide information on the performance of the structure. To minimize efforts for the investigation, a minimum number of samples should be taken to verify possible ASR problems in the concrete. If ASR is not found, then no further investigation is necessary. Following the identification of ASR as a concern, a more extensive sampling program should be initiated to obtain representative samples for testing.

The scope of the testing program, which may include techniques such as density, strength, elasticity, air content, physical effects, chemical effects, permeability, thermal expansion, etc., will govern the number and size of specimens needed. Where ASR is of consideration and time rate studies are of interest, samples for tests should be identified and obtained (Table 2).

No universally accepted test is recognized to assure definitive answers to questions associated with ASR in concrete structures. Generally, the same questions arise for structures not affected by ASR as for those suffering from ASR deterioration, e.g., questions regarding concrete strength, cause for deterioration, service life expectancy of the structure, and steps necessary to extend the service life of the structure.

Obtaining hand samples, grab samples, and/or shallow cores is probably sufficient to determine the presence of ASR. However, where grab samples or hand samples are obtained, the physical property of the concrete is sufficiently altered so that the sample would not be useful in determining physical properties of the concrete.

Other methods of sampling include cutting beams and coring. Cutting beams is generally more costly, and samples tend to have limited utility in that sampling is confined to relatively shallow thin members. Coring remains the

Table 2 Recommended Tests

CRD Standard	ASTM Standard	Test
C-57	C 856	Petrographic examination of hardened concrete concrete
C-14	C 39	Compressive strength of cylindrical concrete specimens
C-127	C 295	Petrographic examination of aggregates for concrete
C-140	C 342	Potential volume change of cement-aggregate combinations
C-123	C 227	Potential alkali reactivity of cement-aggregate combinations
C-128	C 289	Potential reactivity of aggregates (chemical method)
NA	C 1260	Potential alkali reactivity of aggregates (mortar-bar method)
C-269	C 1218	Water-soluble chloride in mortar and concrete
C-30	C 85	Cement content of hardened portland-cement concrete
C-85	C 1084	Portland-cement content of hardened hydraulic-cement concrete

most common and economical method for taking samples from structures. Coring allows samples to be obtained from the interior of a mass concrete structure. Deteriorated concrete involving ASR commonly is limited to the upper 3 ft, whereas the interior concrete deterioration tends to be associated with structural openings. Samples of the interior concrete should be sampled as well as the exterior concrete.

Recommended core sizes depend on the availability of the required test and test equipment. For most testing purposes, cores with a diameter 2.5 times the maximum size coarse aggregate and a length-to-diameter ratio of 2:1 are adequate; however, because the investigation of ASR involves dimension measurements, core lengths of 10 to 12 in. are more suitable.

It is not the intent of this technical note to describe details of coring operations. It is recommended that sampling of the concrete should be done to minimize damage to the cores. A triple wall core barrel with a diamond bit has been found to be best suited for most concrete sampling.

Basic information of the cores should include core location, diameter, length, orientation, fractures, cold joints, disintegration of core, number of pieces, presence of reinforcement, and presence of damp patches and gel in cracks and voids. When possible, a photographic record of the core is beneficial.

Immediately after being obtained, the samples should be protected from desiccation and carbonation. Cling-type plastic wrap may be used, followed by sealing in a heavy plastic bag to further protect the samples. Waxing the cores and core boxes for transportation will protect previously damaged concrete from further deterioration due to handling.

Samples of water and soil that come in contact with the concrete should also be obtained where those items are believed to contribute to the potential for ASR damage.

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